Treatment strategies and outcomes in patients with infected aortic endografts

Javairiah Fatima, MD, Audra A. Duncan, MD, Eileen de Grandis, MD, Gustavo S. Oderich, MD, Manju Kalra, MD, Peter Gloviczki, MD, and **Thomas C. Bower, MD,** *Rochester, Minn*

Objective: **Endovascular abdominal (EVAR) and thoracic (TEVAR) endografts allow aneurysm repair in high-risk patients, but infectious complications may be devastating. We reviewed treatment and outcomes in patients with infected aortic endografts.**

Methods: **Twenty-four patients were treated between January 1997 and July 2012. End points were mortality, morbidity, graft-related complications, or reinfection.**

Results: **Twenty males and four females with median age of 70 years (range, 35-80 years) had 21 infected EVARs and 3 TEVARs. Index repairs performed at our institution included eight EVARs and two TEVARs (10/1300; 0.77%). There were 19 primary endograft infections, 4 graft-enteric fistulae, and 1 aortobronchial fistula. Median time from repair to presentation was 11 months (range, 1-102 months); symptoms were fever in 17, abdominal pain in 11, and psoas abscess in 3. An organism was identified in 19 patients (8 mono- and 11 polymicrobial); most commonly *Staphylococcus* in 12 and *Streptococcus* in 6. All but one patient had successful endograft explantation. Abdominal aortic reconstruction was in situ repair in 21 (15 rifampin-soaked, 2 femoral vein, and 4 cryopreserved) and axillobifemoral bypass in three critically ill patients. Infected TEVARs were treated with rifampin-soaked grafts using hypothermic circulatory arrest. Early mortality (30 days or in-hospital) was 4% (n = 1). Morbidity occurred in 16 (67%) patients (10 renal, 5 wound-related, 3 pulmonary, and 1 had a cardiac event). Median hospital stay was 14 days (range, 6-78 days). One patient treated with in situ rifampin-soaked graft had a reinfection with fatal anastomotic blowout on day 44. At 14 months median follow-up (range, 1-82 months), patient survival, graft-related complications, and reinfection rates were 79%, 13%, and 4%, respectively.**

Conclusions: **Endograft explantation and in situ reconstruction to treat infections can be performed safely. Extra-anatomic bypass may be used in high-risk patients. Resection of all infected aortic wall is recommended to prevent anastomotic breakdown. Despite high early morbidity, the risk of long-term graft-related complications and reinfections is low. (J Vasc Surg 2013;58:371-9.)**

The endovascular approach to aortic aneurysm repair was initially developed as an alternative to open repair in the otherwise medically unfit or poor surgical candidates. However, over time, this has become the preferred approach with lower perioperative morbidity, mortality, and shorter hospital stay, with outcomes comparable to that of open approach.[1,2] Unfortunately, complications of abdominal endovascular aneurysm repair (EVAR) and thoracic endovascular aneurysm repair (TEVAR) may require treatment that is more complex and high risk than if the original procedure was done with an open technique, such as the management of the infected endograft.

Infection of prosthetic endograft is rare but is a devastating complication associated with high mortality. This makes it imperative that it be recognized early with aggressive workup and optimal treatment to improve outcome.

Table I. Cardiovascular comorbidities

Comorbidities	%
Hypertension	89
Hyperlipidemia	72
Coronary artery disease	67
Peripheral vascular disease	28
Chronic renal insufficiency	28
Diabetes	6
Tobacco use	94
Immunosuppressive	11

The incidence of infected abdominal and thoracic aortic endografts varies from 0.2% to 5% based on case reports and small case series.[3-9] The current series is aimed at providing a diagnostic and treatment algorithm based on our experience with infectious complications after abdominal and thoracic endovascular aortic aneurysm repairs.

METHODS

After approval from the Institutional Review Board, the surgical index and database were queried to identify all consecutive patients who underwent endovascular repair of aortic aneurysms at the Mayo Clinic between January 1997 and July 2012. The search was broadened to find all patients with the diagnosis of infected endograft at the Mayo Clinic in order to capture all cases, whether

From the Division of Vascular and Endovascular Surgery, Mayo Clinic.

Author conflict of interest: none.

Presented at the Thirty-fifth Annual Meeting of the Midwestern Vascular Surgical Society, Chicago, Ill, September 15-17, 2011.

Reprint requests: Audra A. Duncan, MD, Gonda Vascular Center, Mayo Clinic, 200 First St, SW, Rochester, MN 55905 (e-mail: duncan.audra@mayo.edu).

0741-5214/$36.00

http://dx.doi.org/10.1016/j.jvs.2013.01.047

Table II. Patient demographics, presentation, treatments, and outcomes

Pt	*Age*	*Gender*	*Time from symptoms to presentation, days*	*Primary endovascular procedure*	*Presenting symptoms*	*Positive radiographic imaging*
1	74	M	151	EVAR	Fever	CT, WBC scan
2	74	M	1856	EVAR	Fever, ruptured aneurysm	CT
3	68	M	71	EVAR	Fever, night sweats, urosepsis	CT, WBC scan
4	63	M	525	EVAR	Fever, night sweats, weight loss	CT, WBC scan
5	70	M	60	EVAR	Fever, abdominal pain, groin abscess	CT, WBC scan
6[c]	68	F	693	EVAR	Abdominal pain	CT, WBC scan
7	71	M	88	TEVAR	Fever, night sweats	CT
8	67	M	662	EVAR	Abdominal pain	CT, WB scan
9[c]	68	F	254	EVAR	Fever, contained rupture	CT
10	70	M	482	EVAR	Psoas abscess, abdominal pain	CT, WBC scan
11	74	M	2451	EVAR	Fever, abdominal pain, night sweats, urosepsis	CT, WBC scan
12	71	M	156	EVAR	Fever, abdominal pain, groin abscess	CT
13	60	M	608	EVAR	Psoas abscess, abdominal pain	CT, WBC scan
14	78	M	3045	EVAR	Fever	CT, WBC scan
15	35	F	33	TEVAR	Fever, hempotysis aortobronchial fistula	CT, WBC scan
16	62	M	150	EVAR	Fever, discitis, bacteremia	CT, WBC scan
17	61	F	44	EVAR	Abdominal pain, muscle spasms	CT
18	79	M	797	EVAR	Urosepsis	CT
19[c]	74	M	2815	TEVAR	Abdominal pain, flu-like symptoms	CT, WBC scan
20	62	M	365	EVAR	Fever	CT, WBC scan
21	64	M	244	EVAR	Fever, abdominal pain	CT
22[c]	73	M	308	EVAR	Psoas abscess, fever, night sweats	CT, WBC scan
23[c]	80	M	1689	EVAR	Fever, abdominal pain	CT, WBC scan
24	72	M	137	EVAR	Fever, GI bleed, sepsis	CT

ARF, Acute renal failure; *CT,* computed tomography; *DVT,* deep vein thrombosis; *EVAR,* endovascular aneurysm repair; *GI,* gastrointestinal; *GPC,* gram-positive coccal; *MI,* myocardial infarction; *MRSA,* methicillin-resistant *Staphylococcus aureus*; *TEVAR,* thoracic endovascular aneurysm repair; *WBC,* white blood cell.

[a]All but one patient had been on antibiotics prior to presentation.

[b]Partial graft excision for limited infection.

[c]While the cultures remained negative in these patients, the preoperative radiographic and intraoperative findings were diagnostic for endograft infection.

[d]Cryopreserved.

the index repair was performed at Mayo Clinic or an outside facility. Infection of aortic endograft was defined as radiographic finding of perigraft fluid or abscess, clinical presentation of the patient, positive blood or aortic wall cultures, and intraoperative findings of infection, purulence, or inflammation. Aortoenteric graft erosion or fistula was defined as loss of fat plane between bowel and aortic wall, herald bleed followed by visual confirmation on endoscopy, and intraoperative finding of aortoenteric communication with evidence of enteric staining of the endograft prosthesis on explantation. Data acquisition was performed in a retrospective fashion from patient medical records including their preoperative cardiovascular risk factors, clinical signs and symptoms at presentation, and perioperative management. End points included survival, early and late postoperative complications including reinfection, and graft-related complications such as limb occlusion or aneurysm recurrence. The early perioperative period was defined as duration of the index hospitalization regardless of the number of days or within 30 days of the operation. This information was then used to determine a preferred treatment strategy for patients with infected endovascular grafts.

Statistics. All categorical data are expressed as mean ± standard error of the mean or median (with range) as appropriate.

RESULTS

Twenty-four patients, with 21 abdominal aortic and three thoracic stent grafts, were treated at the Mayo Clinic

Table II. Continued.

Microbiology[a]				
Blood culture	*Aortic wall culture*	*Procedure performed*	*Early outcome*	*Late outcome*
Streptococcus	*Enterobacter*, *Staph*, *Strep*	In situ reconstruction	Lymph leak	
	Gemella morbillorum, *Fusobacterium*	In situ reconstruction	Seroma	
	Staph aureus	In situ reconstruction	ARF	
	Staph aureus	In situ reconstruction		
	Staph aureus	Axillobifemoral graft In situ reconstruction[b]	DVT, death	
	Bifidobacterium adolescentis, *Staph aureus*, *Candida*, *Pseudomonas*	In situ reconstruction	ARF	
Staph aureus	*Staph aureus*	Axillobifemoral graft In situ reconstruction[b]	ARF, infected groin hematoma	Occluded ABF graft requiring lytic therapy
Streptococcus	*Streptococcus*	In situ reconstruction	ARF DVT	
Staph aureus	*Staph aureus*	In situ reconstruction	ARF	
Staph aureus	*Pseudomonas*	In situ reconstruction[d]		
Candida	*Prevotella*, *Candida*, Coag negative *Staph*	In situ reconstruction		
	Enterococcus, *Peptostreptococcus*, *Candida*, *Staph*	Axillobifemoral graft	Prolonged vent support	
	Prevotella, *Strep viridans*	In situ reconstruction	ARF, groin hematoma, prolonged vent support	
MRSA	MRSA	In situ reconstruction		Reinfection + proximal anastomotic blowout
	Staph aureus	In situ reconstruction[b]	Chyle leak	
Salmonella	*Pseudomonas*	In situ reconstruction[d]	ARF, Afib	
		In situ reconstruction	Death	
	Streptococcus, *Candida*, *Prevotella*, *Parvomonas*, *GN Bacilli*	In situ reconstruction		
Strep viridans, *Veillonella*	*Strep viridans*, *Lactobacillus*, *Propionibacterium acnes*	In situ reconstruction[d]	ARF	
		In situ reconstruction		
		In situ reconstruction	ARF, MI	
	Prevotella, GPC	In situ reconstruction[d]	ARF, hemothorax, pneumonia	

for infected endografts between January 1997 and July 2012. During this 15-year period, 1300 patients underwent endovascular aortic stent placement; of these, 1098 were abdominal (EVAR) and 202 were thoracic (TEVAR) endografts. The incidence of infection in patients with index endovascular graft placement at Mayo Clinic for EVARs was 8 of 1098 (0.7%) and 2 of 202 TEVARs (1%).

Patient demographics. Twenty males (79%) and four females with a median age of 70 years (range, 35-80 years) met the inclusion criteria for this cohort. Their comorbidities are depicted in Table I. Twenty of the 24 patients (83%) had at least one alleged risk factor for seeding infection, including one or more secondary endovascular reinterventions (8), aortoduodenal fistulae (4), recurrent urosepsis (3), recurrent episodes of pneumonia (2), colon resection for ischemic colitis (1), appendectomy (1), groin infection (1), epidural abscess (1), or recent history of tooth extraction (1). Indication for index endovascular aortic repair was aneurysmal disease in 22 patients and pseudoaneurysm following a prior open aortobifemoral repair for occlusive disease in two patients using an AneuRx (Medtronic, Minneapolis, Minn) in one patient and a Gore Excluder (Gore, Flagstaff, Ariz) device in the other. The AneuRx graft was retrieved from seven patients, Gore Excluder devices from eight patients, Zenith (Cook, Bloomington, Ind) in four patients, and Ancure (Endovascular Technologies, Menlo Park, Calif), Bolton (Bolton Medical, Sunrise, Fla), and PowerLink by Endologix (Irvine, Calif) were found in one each. The remaining two graft devices were not identified.

Presentation. All patients were symptomatic at the time of presentation. The most common symptom was fever and weight loss associated with malaise and signs of systemic illness, abdominal pain, aortoenteric fistulae suspected on preoperative computed tomography (CT) imaging, psoas or groin abscess, and aneurysm rupture (Table II). Median time from start of symptoms to presentation was 17 months (range, 1-102 months).

Diagnostics. One patient was taken to the operating room directly from the emergency room without any preoperative evaluation other than an outside CT with evidence of ruptured aneurysm. The remaining 23 patients underwent extensive workup, including diagnostic tests, preoperative cultures, and/or percutaneous abscess drainage with initiation of antibiotics prior to aortic debridement. When endograft infection is suspected, our institutional algorithm includes computed tomography angiogram (CTA), white blood cell scan, blood cultures prior to initiation of antibiotics when possible, and upper endoscopy in patients presenting with upper gastrointestinal bleed or melena. CTA (Fig 1) at initial presentation demonstrated perigraft fluid collection in 19 patients; periaortic abscess was defined by the presence of air in perigraft fluid in 13 patients. A tagged white blood cell scan (Fig 2) was performed in 16 patients; 15 of these were positive with focus of intense radiotracer uptake. One patient was diagnosed with aortoenteric fistula preoperatively on upper gastrointestinal endoscopy. Nineteen patients had leukocytosis on initial presentation. During the extensive workup for suspected endograft infection, the CTA of one patient (patient #9 in Table II) was concerning for possible rupture, with resultant expeditious operative intervention.

Microbiology. Blood cultures were drawn in all except two patients who had been on prolonged antibiotic therapy prior to presentation. Nine of these patients had positive blood cultures preoperatively. Aortic wall cultures sent intraoperatively were positive in 19 patients. Of these, eight were monomicrobial, and 11 were polymicrobial. The most commonly identified organism was *Staphylococcus aureus* in 12 patients; at least two were methicillin-resistant *Staphylococcus aureus* (MRSA). Other organisms included *Streptococcus*, *Pseudomonas*, *Prevotella*, and *Salmonella baildon* (non-typhi). Four patients had positive fungal cultures (Table II). All except one patient had been initiated on broad-spectrum antibiotics prior to being taken to the operating room.

Operative approach. Explantation of infected aortic endograft was performed in all 24 patients, one emergently and 23 after completion of preoperative workup. All but three patients underwent excision of the entire infected graft; in three patients, the infection was limited to the limb extending proximally from the infected groin, and therefore, excision of the infected limb was undertaken to healthy-appearing tissue, which was then confirmed by negative margin on intraoperative pathology. Four patients had aortoenteric fistula requiring endograft explantation and bowel resection or repair (Fig 3, *A* and *B*).

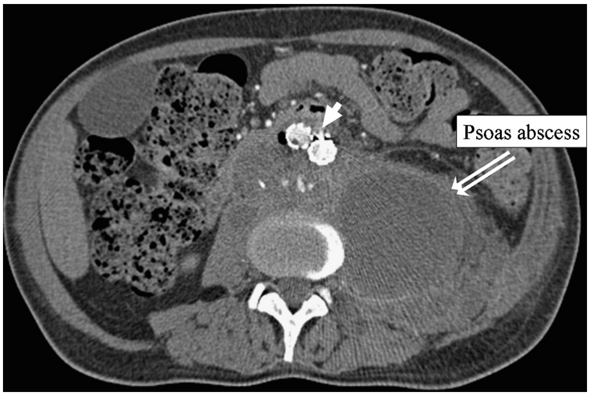

Fig 1. Computed tomography (CT) scan reveals periaortic fluid with gas bubbles (*white arrow*) and psoas abscess (*double arrow*) suggestive of infected aortic aneurysm.

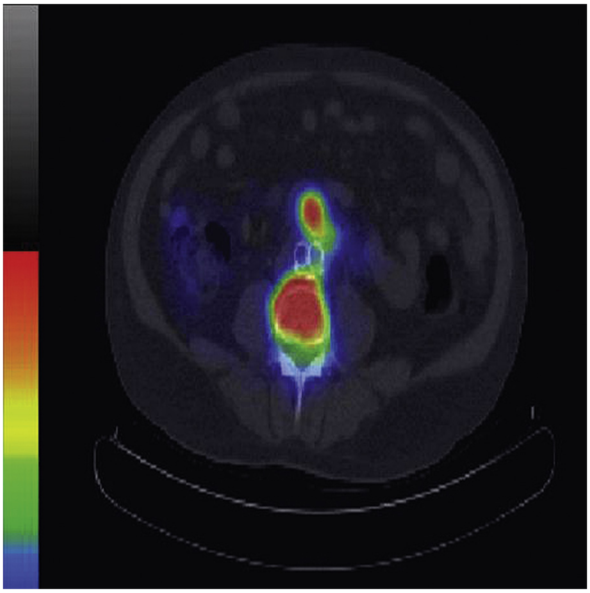

Fig 2. A focus of intense radiotracer uptake is present immediately anterior to the bifurcated aortoiliac graft interposed between the prior aneurysm sac and the transverse duodenum.

If abscess or frank purulence was noted intraoperatively (Fig 4), autogenous vein graft or cryopreserved graft was preferred. In situ reconstruction, our preferred approach in patients without abscess or frank purulence, was performed in 21 patients, including all three thoracic aortic repairs.[10] In situ rifampin-soaked Dacron grafts were utilized in 15 patients, superficial femoral vein graft in two patients, and cryopreserved graft (CryoLife, Inc, Kennesaw, Ga) in four patients (Fig 5). Rifampin-soaked grafts were prepared by soaking a Dacron graft in 60 mg/mL rifampin solution for 30 to 60 minutes. Cryopreserved grafts were stored at −180°C to −196°C and thawed to 37°C to 42°C prior to use. Three patients deemed high risk for an extensive in situ single-stage operation were

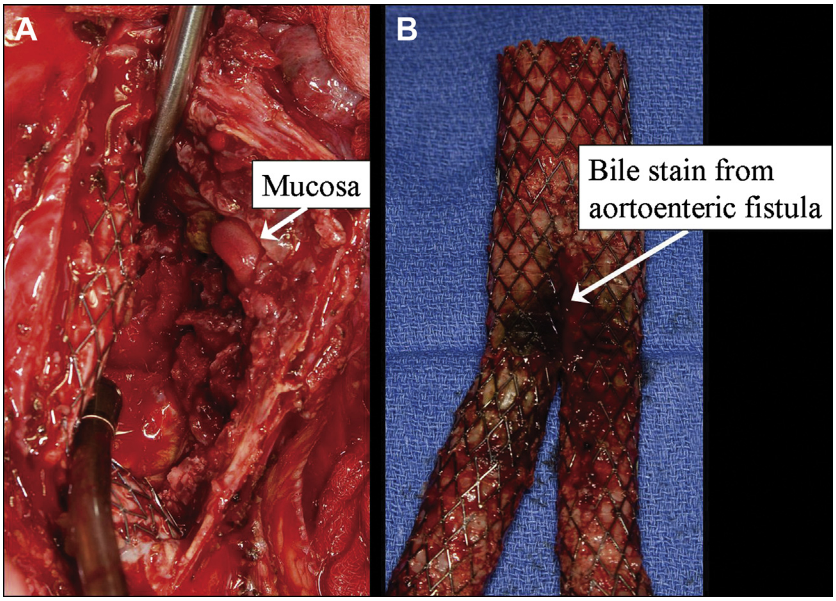

Fig 3. A, Intraoperative findings demonstrating aortoduodenal fistula (*arrow*). **B,** Explanted graft with bile staining (*arrow*).

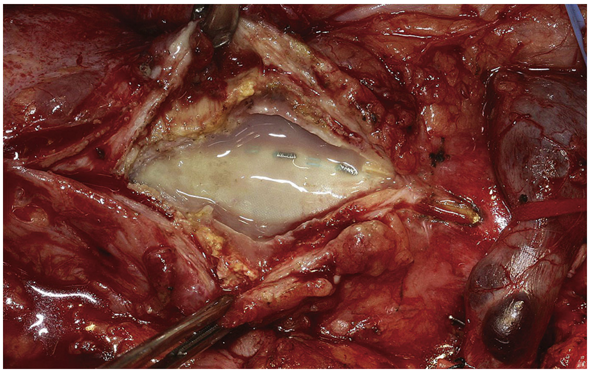

Fig 4. Intraoperative picture of frank perigraft purulence.

treated in a staged fashion with an axillobifemoral graft followed by explantation 48 hours later. One of these patients indeed had a significant amount of purulence and therefore was left with an aortic stump wrapped in a 360-degree omental flap. In the other two patients, we used a staged technique of placing an axillobifemoral graft first, which is a shorter and clean procedure in these high-risk patients. By staging the procedure, we have found that we are able to get very high-risk patients through with lower mortality. At the next procedure, we plan to place an in situ graft, but we have the alternative of oversewing the aorta since the axillobifemoral graft is already in place in a clean field. If the patient becomes unstable, the aorta can be oversewn, and the lower limbs remain perfused.

All patients with thoracic aortic infection required establishment of hypothermic circulatory arrest to accomplish infected graft explantation and in situ reconstruction. One of the patients with an infected thoracic endograft had previously been treated with open repair for aortic coarctation complicated by an aortobronchial fistula for which she underwent endograft placement. At the time of transfer to our facility 33 days postoperatively, she was critically ill, septic, and on heavy pressor support. Extra-anatomic ascending aorta to descending thoracic aortic bypass with rifampin-soaked Dacron grafts was performed with endograft explantation, followed by extracorporeal membrane oxygenation for respiratory support. A pedicle of diaphragm was wrapped around the anastomosis, and the aortic stump was buttressed with bovine pericardium. The postoperative course was complicated with bleeding, acute renal failure, and respiratory failure requiring tracheostomy. After a prolonged hospital stay of 64 days, the patient was discharged with no sequelae at 6-month follow-up. One patient with a history of prior open type III thoracoabdominal aortic aneurysm repair followed by multiple thoracic stent grafts developed persistent infection for which he underwent endograft explantation with rifampin-soaked grafts. Despite successful technical repair, the patient failed resuscitation after cardiopulmonary arrest.

Three patients had focal infection of one limb of the bifurcated aortic stent, associated with groin abscesses. These patients had focal areas of infection based on CTA and white blood cell scan, as well as intraoperative appearance and confirmation by pathology. We often send intraoperative histology to look at frozen section for white blood cells and bacteria in the aortic wall to confirm whether more artery should be removed. Given the above evidence of localized infection and baseline poor clinical status of the patients, the decision was made to not explant

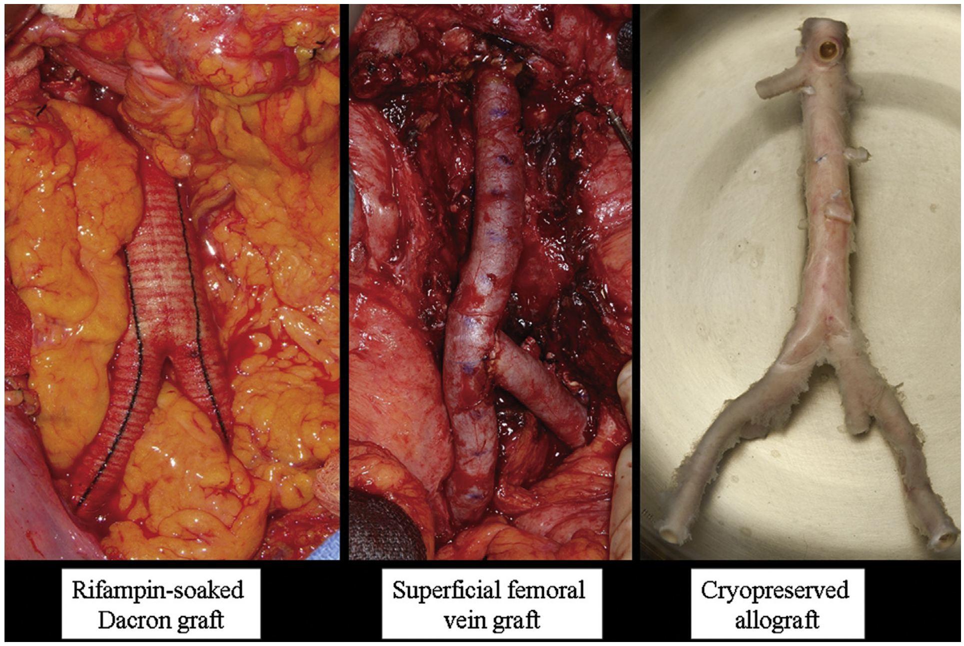

Fig 5. After explantation of infected endograft, in situ reconstruction is the preferred repair using three different graft materials as indicated: rifampin-soaked Dacron, autogenous vein, or cryopreserved graft.

the entire graft and subject the patient to an operation of much greater morbidity. These patients were maintained on life-long suppressive antibiotics and have done well with no evidence of residual infection.

Partial graft excision was performed with complete eradication of infected tissue and preservation of healthy uninfected aortoiliac graft. Local primary in situ reconstruction was performed in two patients. In the third patient, axillounifemoral bypass was performed using rifampin-soaked Dacron grafts (proximal two-thirds) and reversed femoral vein grafts in the distal one-third due to excessive groin purulence. All in situ reconstructions were protected with autogenous 360° tissue coverage using omental flaps when available (14 patients; Fig 6); rectus femoris muscle flap and fascia lata were used in the remainder. Aortic sac was closed over the reconstruction in one patient due to the lack of omental tissue. Serratus anterior and diaphragm pedicle wrap were used for coverage in the two patients with thoracic repairs.

Postoperative antibiotics. Antibiotic treatment was continued for life in 14 of the 23 patients alive (61%). These patients either had more virulent microorganisms on culture, prosthetic graft as conduit, or partial excision of the endograft (infected segment was removed). Antibiotics were continued for a period of 6 weeks based on cultures and susceptibilities in patients with autogenous tissue, minimal risk factors for reinfection, and less virulent microorganisms on culture. None of these patients had any evidence of reinfection or developed resistance or allergies to antibiotics at the time of last follow-up.

OUTCOMES

Overall survival. There was one early (in-hospital or 30-day) mortality; four others died at 2, 3, 10, and 66 months. Overall survival was 79% at last follow-up (Table III). One patient died intraoperatively, and one due to graft reinfection with anastomotic blowout on postoperative day 44. The cause of death in the remaining three patients was not attributable to graft-related complications or reinfection. Median length of hospital stay was 14 days (range, 6-78 days). Median follow-up for this cohort was 14 months (range, 1-82 months). These patients are followed up 4 to 6 weeks postoperatively to assess early complications and reassess antibiotic needs, then at 3 to 6 months after operation with a CT scan. If they remain stable, they are followed annually to ensure late complications are diagnosed and addressed. While no patients were lost to follow-up, 8 of these 24 patients were treated within the last year.

Early. One patient died intraoperatively. Postoperative complications occurred in 17 patients (71%) including acute renal failure, deep vein thrombosis, hematoma treated with operative exploration and evacuation, seroma, and lymph leak (Table II).

Late. Major complications occurred in four patients (17%) including the patient with anastomotic blowout due to reinfection. One patient developed acute symptomatic occlusion of the axillobifemoral bypass 1 year postoperatively and was treated with thrombolytic therapy with excellent results. Two patients developed aneurysm recurrence at the proximal anastomotic site; one was repaired with an endovascular stent placement, while the other

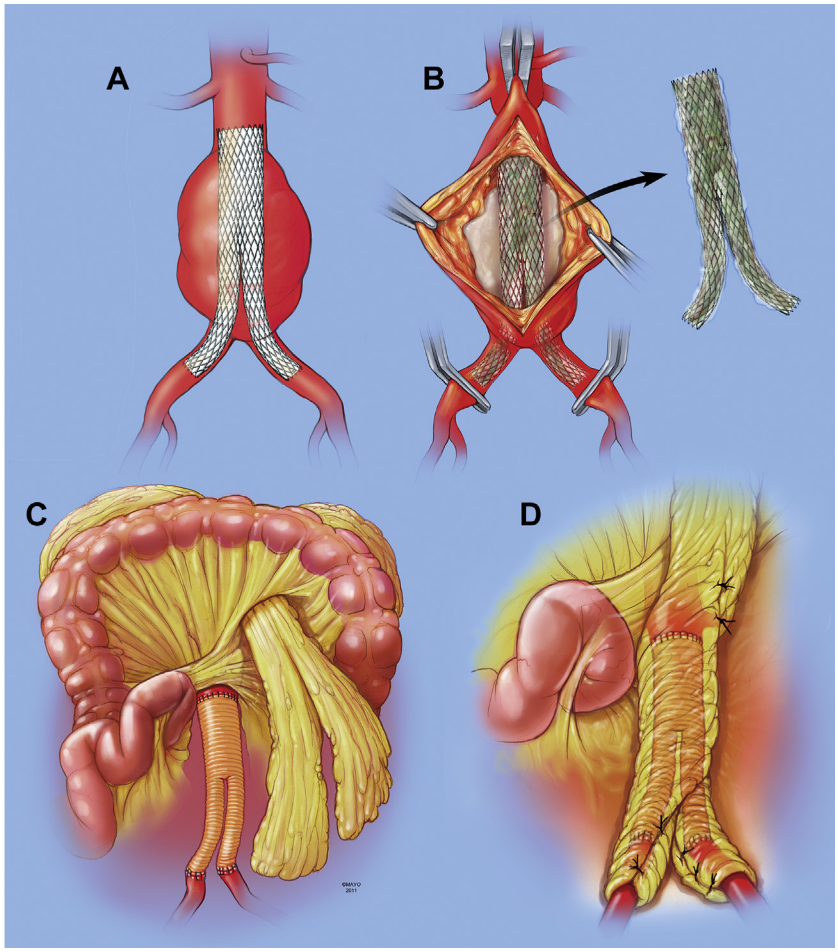

Fig 6. Technique for explantation of infected aortic endograft and replacement with in situ rifampin-soaked Dacron grafts. **A,** In situ endograft preoperatively. **B,** Proximal and distal controls are established and the infected endograft is removed with debridement of all infected tissue. **C,** Rifampin-soaked Dacron graft is used to replace the endograft. **D,** A tongue of omentum is brought retrocolic, and a 360° omentum wrap is performed.

Table III. Outcome in patients with infected aortic endografts after explantation

Overall survival, No. (%)	19/24 (79)
Early (30-day) mortality, No. (%)	1/124 (4)
Early morbidity, No. (%)	17/24 (71)
Graft-related complications, No. (%)	4/24 (17)
Reinfection, No. (%)	1/24 (4)
Median hospital stay, days (range)	14 (6-78)
Median follow up, months (range)	14 (1-82)

required an open repair. Overall freedom from graft-related complications was 87% at median follow-up of 14 months (range, 1-82 months).

DISCUSSION

With advancements in endograft technology, and improvement in device design and delivery mechanisms, the endovascular approach has become a widely accepted and most commonly utilized approach for aortic aneurysm repair. While only a small fraction of patients undergoing endovascular repair for aortic aneurysms are faced with the challenging problem of endograft infection, the absolute increase in numbers raises the concern regarding the ideal treatment strategy for this subset of patients. Literature on open aortic infections reports an incidence of 0.2% to 3%.[10] Numan et al and Setacci et al have compiled data from case reports and case series in published literature from multiple institutions in order to review preoperative workup, different treatment options undertaken, and their outcomes.[11,12] Our experience with this largest single-center cohort is similar to those quoted in these reviews. This study shows that the infection rate in patients undergoing endovascular aortic aneurysm repair is comparable to that of open aortic repairs (0.6%). Other authors have reported a similar incidence of <1% for abdominal aortic graft infections and as high as 5% for thoracic aortic graft infections.[3,4,6-8]

Graft-enteric fistulae occurred in 0.3% of all endograft repairs at our institution; we hypothesize it occurs secondary to stent migration, severe angulations causing repetitive frictional wear/tear, and possibly also due to fixation hooks resulting in endograft erosion through the aortic wall into the duodenum. The clinical presentation of infected endografts is similar to that of infection after open repair with non-specific signs such as fever, weight loss, malaise, and abdominal pain. Also similar was the extensive workup including blood cultures, CTA, and tagged white blood cell scan followed by cardiopulmonary workup to determine the best operative approach. The presence of positive cultures, perigraft fluid with the presence of air therein, or associated psoas or groin abscess was indicative of an infected endograft. Two patients in our series while in the process of being worked up for suspected infection presented with contained rupture.

Twenty of the 24 patients were found to have historical characteristics that may have been risk factors for infection. Vogel et al identified the presence of perioperative septicemia as a risk factor for graft infection in the study.[13] Eight patients had at least one invasive secondary intervention related to an endoleak. Three patients had multiply recurrent urinary tract infections, and two patients had pneumonia during the period from index repair to presentation with an infected endograft. One patient had a recent history of a dental procedure. While there is no evidence that secondary interventions, perioperative infection, and sepsis are risk factors, it may be that these patients are susceptible to endograft infections.

Our management of patients with infected aortic endografts is based on lessons learned and results from our open aortic graft infections, and we have experienced low reinfection rates (4%; n = 1) and graft-related morbidity (13%) with infected endograft patients.[14-17] While axillobifemoral bypass graft once was considered the only viable option for treatment of infected aortic grafts, we have shied away from them secondary to the associated high risk of aortic stump disruptions (20%), amputation rate of 20% to 29%, and a reinfection risk of up to 20%.[11,15,17,18] Also, this may not be a feasible approach for patients with para-visceral or thoracoabdominal aneurysms, in patients with suprarenal fixation, or those with poor quality of tissues. In our experience, mortality associated with in situ reconstruction for infected open aortic grafts was 8% with 100% limb salvage.[16,19] All our aortoenteric fistulae in the open series (n = 54) were treated with in situ repair with a mortality rate of 2.3% and a reinfection rate of 4%.[19] Rifampin-soaked polyester grafts wrapped 360° in autogenous tissue (preferably omentum) was the conduit of choice in our open as well as endograft infections.[4,19]

In patients bacteremic with virulent micro-organisms or when frank purulence or a large abscess was encountered intraoperatively, we opted to use autologous vein graft, and more recently, have preferred to use cryopreserved graft (4 of 24 patients), as it obviates the prolonged operative time required for deep vein harvesting, especially in urgent situations or in patients with high cardiopulmonary risk who cannot tolerate prolonged anesthesia.[20] Cryopreserved arterial grafts have been shown to be more resistant to reinfection and promising outcomes with lower mortalities of 5% to 9%, 100% limb salvage, and 2% aneurysmal degeneration, as also noted by Setacci et al.[11,21-25] However, we acknowledge that cryopreserved allografts are significantly more expensive than antibiotic-soaked prosthetic grafts. Use of spiral vein reconstruction is another option that has recently been described by Van Zitteren et al and involves harvesting greater saphenous vein, which is then cut open longitudinally and tightly placed on a 15-mm-diameter tube to construct a suitably fitting graft, using continuous sutures (Vascufil 6/0) with 1-mm intervals. This is then used for in situ aortic reconstruction.[26]

Nonexcisional therapy for treatment of infected aortic endografts has met with high mortality rates ranging from 33% to 70%.[3-5,11,27] At our institution, we have not managed any infected endografts nonoperatively. We advocate removal of all infected material followed by reconstruction and antibiotic suppressive therapy. In high-risk patients, we have opted for staged extraanatomic revascularization first to reduce cardiac afterload and allow shorter, albeit two or more, procedures.

All patients at our institution were initiated on antibiotic therapy as soon as endograft infection was suspected and cultures were drawn. Patients remained on therapy during the period of workup, perioperatively, and were continued for a 4- to 6-week period intravenously. If virulent organisms were encountered, abscess or frank purulence was noted intraoperatively, or if partial excision of graft was undertaken, oral antibiotics were continued as life-long suppressive therapy. Patients with autogenous venous conduit and favorable risk factors and those with negative blood and aortic wall cultures were treated with a finite period of antibiotic therapy. Neither group of patients had any evidence of reinfection at a median follow-up of 14 months. There is currently no consensus or data that recommend an appropriate duration of antibiotics in this group of complex patients, and therefore, it is largely determined by patient presentation, degree of purulence noted intraoperatively, choice of conduit (autogenous vs prosthetic), patient risk factors for reinfection, and virulence of cultured organisms.[28,29]

CONCLUSIONS

Based on our experience in these 24 patients, infected aortic abdominal and thoracic endografts can be treated safely and effectively by device explantation with in situ reconstruction. While rifampin-soaked Dacron graft is our preferred choice in most cases, when faced with infection with virulent organisms or frank purulence such as an abscess, autologous grafts (vein or cryopreserved) may be a better choice. Extra-anatomic reconstruction may be considered in high-risk patients. Perioperative complications occurred frequently, and graft-related late complications occurred in 12.5% of our patients. Endograft explantation with suppressive antibiotics appears to be associated with a low risk of reinfection.

AUTHOR CONTRIBUTIONS

Conception and design: JF, AD
Analysis and interpretation: JF, AD
Data collection: JF, EG
Writing the article: JF, AD, GO
Critical revision of the article: JF, AD, EG, GO, MK, PG, TB
Final approval of the article: JF, AD, EG, GO, MK, PG, TB
Statistical analysis: JF, AD, EG
Obtained funding: AD
Overall responsibility: JF, AD

REFERENCES

1. Greenhalgh RM, Brown LC, Kwong GP, Powell JT, Thompson SG. Comparison of endovascular aneurysm repair with open repair in patients with abdominal aortic aneurysm (EVAR trial 1), 30-day operative mortality results: randomised controlled trial. Lancet 2004;364:843-8.
2. Prinssen M, Verhoeven EL, Buth J, Cuypers PW, van Sambeek MR, Balm R, et al. A randomized trial comparing conventional and endovascular repair of abdominal aortic aneurysms. N Engl J Med 2004;351:1607-18.
3. Cernohorsky P, Reijnen MM, Tielliu IF, van Sterkenburg SM, van den Dungen JJ, Zeebregts CJ. The relevance of aortic endograft prosthetic infection. J Vasc Surg 2011;54:327-33.
4. Ducasse E, Calisti A, Speziale F, Rizzo L, Misuraca M, Fiorani P. Aortoiliac stent graft infection: current problems and management. Ann Vasc Surg 2004;18:521-6.
5. Heyer KS, Modi P, Morasch MD, Matsumura JS, Kibbe MR, Pearce WH, et al. Secondary infections of thoracic and abdominal aortic endografts. J Vasc Interv Radiol 2009;20:173-9.
6. Kirkwood ML, Pochettino A, Fairman RM, Jackson BM, Woo EY, Wang GJ. Thoracic aortic endograft explant: a single-center experience. Vasc Endovascular Surg 2010;44:440-5.
7. Laser A, Baker N, Rectenwald J, Eliason JL, Criado-Pallares E, Upchurch GR Jr. Graft infection after endovascular abdominal aortic aneurysm repair. J Vasc Surg 2011;54:58-63.
8. Sharif MA, Lee B, Lau LL, Ellis PK, Collins AJ, Blair PH, et al. Prosthetic stent graft infection after endovascular abdominal aortic aneurysm repair. J Vasc Surg 2007;46:442-8.
9. Chiesa R, Tshomba Y, Kahlberg A, Marone EM, Civilini E, Coppi G, et al. Management of thoracic endograft infection. J Cardiovasc Surg (Torino) 2010;51:15-31.
10. Oderich GS, Panneton JM, Bower TC, Cherry KJ Jr, Rowland CM, Noel AA, et al. Infected aortic aneurysms: aggressive presentation, complicated early outcome, but durable results. J Vasc Surg 2001;34: 900-8.
11. Setacci C, De Donato G, Setacci F, Chisci E, Perulli A, Galzerano G, et al. Management of abdominal endograft infection. J Cardiovasc Surg (Torino) 2010;51:33-41.
12. Numan F, Gulsen F, Solak S, Cantasdemir M. Management of endograft infections. J Cardiovasc Surg (Torino) 2011;52:205-23.
13. Vogel TR, Symons R, Flum DR. The incidence and factors associated with graft infection after aortic aneurysm repair. J Vasc Surg 2008;47: 264-9.
14. Young RM, Cherry KJ Jr, Davis PM, Gloviczki P, Bower TC, Panneton JM, et al. The results of in situ prosthetic replacement for infected aortic grafts. Am J Surg 1999;178:136-40.
15. Seeger JM, Pretus HA, Welborn MB, Ozaki CK, Flynn TC, Huber TS. Long-term outcome after treatment of aortic graft infection with staged extra-anatomic bypass grafting and aortic graft removal. J Vasc Surg 2000;32:451-9; discussion: 460-1.
16. Oderich GS, Bower TC, Cherry KJ Jr, Panneton JM, Sullivan TM, Noel AA, et al. Evolution from axillofemoral to in situ prosthetic reconstruction for the treatment of aortic graft infections at a single center. J Vasc Surg 2006;43:1166-74.
17. Yeager RA, Taylor LM Jr, Moneta GL, Edwards JM, Nicoloff AD, McConnell DB, et al. Improved results with conventional management of infrarenal aortic infection. J Vasc Surg 1999;30:76-83.
18. Kuestner LM, Reilly LM, Jicha DL, Ehrenfeld WK, Goldstone J, Stoney RJ. Secondary aortoenteric fistula: contemporary outcome with use of extraanatomic bypass and infected graft excision. J Vasc Surg 1995;21:184-95; discussion: 195-6.
19. Oderich GS, Bower TC, Hofer J, Kalra M, Duncan AA, Wilson JW, et al. In situ rifampin-soaked grafts with omental coverage and antibiotic suppression are durable with low reinfection rates in patients with aortic graft enteric erosion or fistula. J Vasc Surg 2011;53:99-107; discussion: 106-7.
20. Clagett GP, Valentine RJ, Hagino RT. Autogenous aortoiliac/ femoral reconstruction from superficial femoral-popliteal veins: feasibility and durability. J Vasc Surg 1997;25:255-66; discussion: 267-70.
21. Verhelst R, Lacroix V, Vraux H, Lavigne JP, Vandamme H, Limet R, et al. Use of cryopreserved arterial homografts for management of infected prosthetic grafts: a multicentric study. Ann Vasc Surg 2000;14: 602-7.
22. Chiesa R, Astore D, Piccolo G, Melissano G, Jannello A, Frigerio D, et al. Fresh and cryopreserved arterial homografts in the treatment of prosthetic graft infections: Experience of the Italian Collaborative Vascular Homograft Group. Ann Vasc Surg 1998;12:457-62.
23. Vogt PR, von Segesser LK, Goffin Y, Pasic M, Turina MI. Cryopreserved arterial homografts for in situ reconstruction of mycotic aneurysms and prosthetic graft infection. Eur J Cardiothorac Surg 1995;9:502-6.
24. Vogt P, Pasic M, von Segesser L, Carrel T, Turina M. Cryopreserved aortic homograft for mycotic aneurysm. J Thorac Cardiovasc Surg 1995;109:589-91.
25. Leseche G, Castier Y, Petit MD, Bertrand P, Kitzis M, Mussot S, et al. Long-term results of cryopreserved arterial allograft reconstruction in infected prosthetic grafts and mycotic aneurysms of the abdominal aorta. J Vasc Surg 2001;34:616-22.
26. van Zitteren M, van der Steenhoven TJ, Burger DH, van Berge Henegouwen DP, Heyligers JM, Vriens PW. Spiral vein reconstruction of the infected abdominal aorta using the greater saphenous vein: Preliminary results of the Tilburg experience. Eur J Vasc Endovasc Surg 2011;41:637-46.
27. Saleem BR, Meerwaldt R, Tielliu IF, Verhoeven EL, van den Dungen JJ, Zeebregts CJ. Conservative treatment of vascular prosthetic graft infection is associated with high mortality. Am J Surg 2010;200:47-52.
28. Bandyk DF. Antibiotics-why so many and when should we use them? Semin Vasc Surg 2002;15:268-74.
29. Kirksey L, Brener BJ, Hertz S, Parsonnet V. Prophylactic antibiotics prior to bacteremia decrease endovascular graft infection in dogs. Vasc Endovascular Surg 2002;36:171-8.

Submitted Oct 23, 2012; accepted Jan 24, 2013.